The Effects of Risk on Farmland Values and Returns

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Abstract

The effect of risk on farmland values and returns is analyzed using a capitalization model. County-level models are estimated using spatial econometric techniques. Our results show that riskier regions and growing conditions have both lower land values and higher risk-adjusted rates of return to farmland.

Key words: farmland returns, farmland values, risk, spatial econometrics.

The Effects of Risk on Farmland Values and Returns

The dominance of farmland in the asset and cost structures of U.S. farming suggests that changes in land values should provide important signals about the risk and competitive positions of agriculture. Theoretical arguments imply that rates of return on farmland should differ to reflect the relative risk positions of different farming environments. Thus, one would expect riskier regions and growing conditions to have both lower land values and higher risk-adjusted rates of return to farmland. While numerous studies have considered different attributes of farmland values, land sale transactions, and farmland leasing arrangements, the measurement of the effects of different risk positions has been conspicuously absent. The lack of attention in the literature to date is due in part to difficulties in developing suitable disaggregated data series for values and returns in which measures of risk effects could likely be detected, and in controlling for non-farm influences in farmland values. Only Chavas and Jones found a significant relationship between land values and the variability of farm income, while Chavas and Thomas found significant relationships between land values, risk aversion, and transaction costs. These analyses, however, employed aggregate data and did not seek to evaluate these relationships across regions and farm enterprise conditions. Moreover, none had directly available measures of economic productivity to relate to verifiable land sale prices.

A recent trend in the land valuation literature is the increased use of spatial econometrics methods (Anselin). Farmland values, rates of return to farmland, and risk measures are geocoded by the county where the farms are located. This spatial heterogeneity of farmland leads to the use of spatial econometrics to account for the effects of unobservable variables that are correlated across counties. Hardie, Narayan, and Gardner tested and corrected for possible spatial autocorrelation for county-level farmland and residential housing values. They considered a simultaneous equations model of farmland and housing prices and found that non-farm factors play significant roles in determining farmland prices. Their analysis, however, explored only the relationship between farmland and residential housing values and did not consider land rents and rates of returns to farmland. Benirschka and Binkley found that land price variation increases with distance to the market. These studies indicate that farmland prices may be further explained by the effects of missing variables that are potentially correlated across counties.

This paper examines the extent to which farmers receive returns to risk bearing through land pricing relationships. To do so, the study uses a unique, high quality set of data on actual farmland sales to construct county-level measures of farmland values. Extensive cash and share farmland rental data from the Illinois Farm Business Farm Management record keeping association are used to develop measures of returns and return variability. Additional measures to control for differences in productivity and non-farm development potential are included to further isolate the effects that can be attributed to risk differences. The study's objectives are: 1) to develop measures of farmland values, rates of return to farmland, and variability of farmland returns; 2) to econometrically test the hypothesis that land values are negatively related and rates of return to farmland are positively related to variability in rents, given other farm, locational and risk management characteristics; and 3) to test and correct for possible spatial autocorrelation between land values and rates of returns in neighboring counties.

Theoretical Models

The modeling approach used is motivated by standard capitalization arguments combined with certain equivalent approaches for incorporating risk effects. The framework is extended to include the influence of other variables affecting returns and values, and estimated within a framework that accommodates spatial dependence to account for the influence of other missing variables that may exert influences on farmland values and returns.

The basic valuation approach is to estimate farmland current market value by capitalizing its flow of expected future earnings at an appropriate interest rate

$$(1) \qquad P = \sum_{t=0}^{\infty} \frac{R}{(1+i)^t} = \frac{R}{i}$$

where P is the current price of farmland, R is the rent for leased land, i is the appropriate risk-adjusted discount rate, and t is the time period. Equation (1) is the standard capitalization formula assuming that future rents are known with certainty. If future rents are uncertain then the effects of risk and risk aversion can be measured by a risk premium defined as an ex-ante income compensation for risk bearing:

$$(2) \qquad P = \frac{R - \lambda\sigma^2}{i} = \frac{1}{i}R - \frac{\gamma}{i}\sigma^2$$

where γ is farmers' risk aversion coefficient, and σ^2 is the variance of rents. Equation shows that farmland with high rent volatility will have a lower current price, all else equal. Rearranging equation (2) highlights that the risk-adjusted rate of return (R / P) is higher for farmland with higher risk per unit value.

(3) $$\frac{R}{P} = i + \gamma \frac{\sigma^2}{P}$$

Equations (2) and (3) are estimated using county-level data for prices and rates of return to farmland. We test the hypotheses that land values are negatively related and rates of return to farmland are positively related to variability in rents, given other farm, locational and risk management characteristics.

The use of geographical cross-sectional data permits the use of spatial econometrics techniques to reflect spatial dependence among the data, and control for missing variables that are spatially correlated. Two alternative forms of spatial dependence are the spatial lag model and the spatial error model (Anselin). The spatial lag model specifies a covariance structure for the dependent variable whereas the spatial error model specifies a covariance structure for the error term. The spatial lag model includes a spatial interaction among county-level land values and rates of return to farmland that comes from the hypothesis that farmland markets are integrated. In other words, the spatial lag model assumes that land values and returns are determined simultaneously across counties. The spatial error model includes a spatial structure for the error terms incorporating the effects of missing variables that are spatially correlated.

Formally, a spatial lag model is expressed as

(4) $$y = \rho W y + X\beta + e$$

where y is the farmland price or rate of return, ρ is a spatial lag coefficient, W is a spatial weight matrix, X is a matrix of exogenous variables described above, β is a parameter vector to be estimated, and e is a vector of error terms. The following reduced-form of the spatial lag model is estimated

(5) $y = (I - \rho W)^{-1} X\beta + (I - \rho W)^{-1} e$.

In other words, the value of the dependent variable *y* is determined by the values of the exogenous variables *X*, not only at county *i*, but other counties, through a spatial weight matrix *W*.

A spatial error model is defined as

(6) $y = X\alpha + u$

where *α* is a parameter vector to be estimated, *u* is a spatially autocorrelated error term, i.e., $u = \lambda W u + e$, and *λ* is a spatial error autocorrelation parameter. The reduced-form of the spatial error model is estimated

(7) $(I - \lambda W) y = (I - \lambda W) X\beta + e$.

Spatial weights are assigned using an inverse distance function, $w_{ij} = 1/d_{ij}$, where d_{ij} is the distance from the centroid of county *i* to the centroid of county *j*. A band is the upper distance is beyond which all weights are assigned to zero. In this analysis, we choose the band to be one half of the maximum distance between counties in the state. Our results are quite robust to this particular choice of band and weight matrix.

Data

The data used for both the land value and rates of return to farmland equations are for 92 counties in Illinois. Ten counties were dropped because of insufficient data on rents. Since we use different datasets for the construction of different variables, we match the data used in this analysis using the county averages for each variable. Definitions and summary statistics for all variables are shown in table 1.

Data on all farmland transactions in Illinois are obtained from the transfer declaration records (commonly called "green sheets") that are required to be filed with the Illinois Department of Revenue. Included for each sale record are sale price, acreage, and county location. In order to exclude land bought and sold for residential purposes, we exclude sales with more than 21 acres and a price higher than $6500 per acre. The county land price is calculated as a simple average of the price per acre of all farmland sales in the county for 1995-1999. An acre-weighted average price was also calculated, but the estimation results were very similar.

Data on rents, variability of rent, tenure, farm size, and soil productivity are obtained from the Farm Business Farm Management Association in Illinois for 1995-1999. Rents are measured as the weighted average of cash rent under a cash lease and the imputed value of the landlord's share under a share lease, with weights being the acres under cash lease and share lease. The variance of rent is calculated at the county level for 1995-1999.

The economic productivity index represents gross crop revenue reflecting local cash basis, cropping patterns, and harvest dates. It is constructed using local prices (basis adjusted) and actual harvest dates, acre weighted across crops to reflect actual rotation practices, and reflects through time variation controlling for point in time differences in aggregate crop conditions. For each county-year, the per acre revenue is calculated as the weighted average of corn and soybean revenues, again reflecting that year's crop percentages and appropriate harvest dates and prices. The revenues are then converted to standardized values in the form of a z-score for each year, and the z-scores are converted to a point on the revenue cumulative distribution function that an acre in each county occupied on average. Thus, this new index provides an improved measure of income potential at a specific location with specific cropping patterns and differences in marketing costs and dates than would soil type ratings alone.

Population data are obtained from the Bureau of Census for 1999. Population density was calculated as the number of people per square mile in a county. We use population density as a proxy for non-farm factors influencing land prices and rates of return.

Table 2 shows the correlation matrix for all variables used in this study. The correlation between land prices and rents is 58.2 percent suggesting that there is a positive relationship which will be analyzed later using the capitalization model. There is also a high positive correlation between the economic productivity index and land prices (61.3 percent) and between the economic productivity index and rents (91.9 percent). These strong relationships show that the economic productivity of farmland is an important factor in determining land values and rents. The correlation between the population density of a county and the average sale price of land is 61 percent implying that the value of land is influenced by the extent of non-agricultural development use.

Estimation Results

Table 3 presents the OLS estimations for the relationships among land prices, rates of return to farmland, rents, risk, and some control variables. The basic regressions shown in table 3 are based on the capitalization formula expressed in equations (2) and (3). The results support our hypotheses that rents have a positive significant effect on land prices and that risk, measured as variance of rents, has a negative significant effect on land prices. The implied discount rate, calculated as one over the coefficient of rents (21.1206) is 4.73 percent for 1995-1999. Risk, measured as the variance of rents per unit of land value, has a positive significant effect on risk-adjusted rates of return to farmland (*R/P*). The implied discount rate found as the intercept in the returns equation is 4.98 percent, which is similar to the discount rate found in the land values equation.

The complete regressions shown in table 3 include several control variables. The effects of rents and risk on land values and returns remain the same. Counties with higher tenure level have lower land values and higher rates of return to farmland. Counties with larger farms tend to have lower land values.

Counties with more productive land do not have higher land values. However, as seen in table 2, the correlation between land prices and productivity is 61.3 percent. Rather than having a direct effect on prices, productivity significantly increases rents (shown as the last regression in table 3) and these higher rents are capitalized into higher prices. More productive farmland implies higher rates of return to farmland.

Land located in more densely populated counties has higher prices and lower rates of return to farmland. The population density variable is a measure of the importance of non-farm activity, such as development of land for residential use.

We test for spatial dependence in the dependent variable and the error term using the LaGrange multiplier test statistic, which is distributed as a chi-square with one degree of freedom (Anselin). The LaGrange test statistics are 14.55 (22.21) for the spatial error model and 15.58 (39.16) for the spatial lag model for the land price (rate of return) equation. They are significant at the 1 percent and therefore the existence of both types of spatial dependence is confirmed. The spatial lag and spatial error models can only be combined for estimation if the weight matrices W of the lag and error term differ, which is not the case here.

Table 4 shows the estimation results for the spatial error models and the spatial lag models. The results for the spatial error models are similar to the OLS estimation results. Rents have a positive significant effect on land prices and risk has a negative significant effect on land prices and positive significant effect on rates of return to farmland. Tenure does not affect land prices or rates of return to farmland and productivity does not affect rates of return in the spatial error model. Farm size has a positive significant effect on returns to farmland in the spatial error model.

The results for the spatial lag model for the land price equation change significantly. Rents and risk do not affect land prices as suggested by the capitalization model. This is an evidence for a strong integration of land markets, where the land prices are mostly influenced by land prices in nearby counties rather than rent or risk considerations. The rest of the results are similar to the OLS results except that farm size becomes insignificant in the land price equation and tenure becomes significant in the returns equation.

Elasticities for the three models are presented in table 5. A 1 percent increase in rents leads to a 0.406 percent increase in land prices for the OLS model, a 0.514 percent increase for the spatial error model, and a 0.098 percent increase for the spatial lag model. In absolute values, a $1 permanent increase in rents will lead to a $7.88 increase in land prices for the OLS model, $9.99 increase for the spatial error model and only $1.90 increase for the spatial lag model. While the magnitude of land price elasticity with respect to rent is similar for the OLS and the spatial error model, the elasticity for the spatial lag model is much lower, due to the smaller (and insignificant) coefficient on rents in the spatial lag model.

Land price elasticities with respect to risk are more stable across different models. A 1 percent increase in the variance of rents leads to a 0.06, 0.046, and 0.022 decrease in land prices for the OLS, spatial error model, and spatial lag model, respectively. A 1 percent increase in the variance of rents per unit of price leads to a 0.106, 0.089, and 0.087 increase in rates of return for the OLS, spatial error model, and spatial lag model, respectively. Price and rates of return elasticities with respect to other control variables are similar in magnitude.

Conclusions

In this paper, we have examined how rents, risk, population density, soil productivity, tenure, and farm size affect land prices and rates of return to farmland. We develop and estimate econometric models where land price is linked to rents and risk via the capitalization formula. Because data are available at a county level, we employed the use of spatial econometrics techniques. We tested and could not reject the spatial error and spatial lag models. Results indicate that farmland that generates riskier income has a lower value, but higher risk-adjusted rates of return than lower risk farmland. Higher population pressure, as expected, contributes significantly to higher values in farmland, as does higher productivity potential. Rental rates are correspondingly lower when the income stream is riskier. Implied capitalization rates can be generated for farmland that differs in average rental income, riskiness of income, and measures of production potential. Finally, the spatial dependence measures among farmland values and rates of return are highly significant and thus important to control for when evaluating implications of risk differences. When farmland market integration is taken into account, the spatial autocorrelation between land prices in neighboring counties dominate the effects of rent and risk on land prices.

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Table 1. Variable Definitions and Summary Statistics

Variable	Definition	Mean	Std Dev	Mini-mum	Maxi-mum
Price	Farmland sale price per acre.	2044.928	790.471	857.523	4288.802
Rent	Rent paid for leasing farmland, calculated as the weighted average of cash rent and the imputed value of share rent.	105.288	29.006	41.027	141.745
Var(Rent)	Variance of rents over time	162.454	131.978	4.607	686.322
Rent/Price	Ratio of rent to price	0.057	0.018	0.025	0.111
Var(Rent)/Price	Ratio of variance of rent over price	0.097	0.106	0.002	0.740
Tenure	Ratio of owned to leased land	0.282	0.108	0.125	0.619
Farm Size	Measured in tillable acres	842.489	252.354	415.748	2352.722
Economic Productivity Index	A z-score measuring soil and economic productivity of farmland	1.560	23.535	-43.900	35.601
Population Density	Population per square mile	96.453	127.731	17.138	773.232

Note: All variables are aggregated at the county level for 1995-1999.

Table 2. Correlation Matrix of Dependent and Independent Variables

Variable	Price	Rent	σ_R^2	*R/P*	σ_R^2/P	Tenure	Farm Size	EPI	Popul. Dens.
Price, *P*	1.000								
Rent, *R*	0.582	1.000							
Var(Rent), σ_R^2	-0.176	0.129	1.000						
Rent/Price, *R/P*	-0.623	0.177	0.325	1.000					
Var(Rent) /Price, σ_R^2/P	-0.434	-0.157	0.887	0.440	1.000				
Tenure	-0.391	-0.503	-0.217	0.057	0.005	1.000			
Farm Size	-0.262	-0.172	0.174	0.163	0.225	-0.299	1.000		
Econ. Product. Index	0.613	0.919	0.046	0.042	-0.242	-0.462	-0.166	1.000	
Population Density	0.610	0.042	-0.219	-0.513	-0.263	-0.082	-0.143	0.117	1.000

Table 3. Regression Models for Land Prices, Rates of Return, and Rents

	Complete Regressions		Basic Regressions	
Variable	Estimate	*t*-ratio	Estimate	*t*-ratio
Price [a]				
Rent	7.8781	1.87 *[b]	21.1206	22.33 **
Var(Rent)	-0.7548	-2.07 **	-1.3197	-2.67 **
Tenure	-1395.9060	-2.54 **		
Farm Size	-0.4505	-2.18 **		
Economic Productivity Index	6.0879	1.22		
Population Density	3.1769	8.52 **		
Constant	1795.2250	3.04 **		
Adjusted R^2	0.71		0.92	
Rent/Price [a]				
Var(Rent)/Price	0.0621	4.19 **	0.0735	4.64 **
Tenure	0.0319	1.87 *		
Farm Size	8.84e-6	1.33		
Economic Productivity Index	0.0002	2.87 **		
Population Density	-0.0001	-4.83 **		
Constant	0.0397	4.28 **	0.0498	21.91 **
Adjusted R^2	0.39		0.18	
Rent [a]				
Var(Rent)	0.0139	1.51		
Tenure	-34.9578	-2.58 **		
Farm Size	-0.0104	-2.01 **		
Economic Productivity Index	1.0462	17.81 **		
Population Density	-0.0152	-1.62		
Constant	121.4577	16.21 **		
Adjusted R^2	0.89			

Notes: [a] Number of observations: 92 counties in Illinois.
[b] ** Significant at the 5 percent level; * significant at the 10 percent level.

Table 4. Spatial Econometrics Models for Land Prices and Rates of Return

Variable	Spatial Error Models Estimate	Spatial Error Models *t*-ratio	Spatial Lag Models Estimate	Spatial Lag Models *t*-ratio
Price [a]				
Rent	9.9895	2.37 **[b]	1.8970	0.48
Var(Rent)	-0.5819	-1.74 *	-0.2825	-0.84
Tenure	-776.9250	-1.54	-1238.5430	-2.55 **
Farm Size	-0.3696	-1.98 **	-0.2259	-1.20
Economic Productivity Index	6.0116	1.34	5.9611	1.36
Population Density	2.7343	7.98 **	2.5882	7.37 **
Constant	1395.0760	2.06 **	627.4226	1.09
Spatial Coefficient (λ or ρ)	0.9007	9.08 **	0.7537	4.69 **
Pseudo $R^{2,(c)}$	0.85		0.88	
Log-likelihood	-677.94		-677.10	
LaGrange Test [d]	14.55	**	15.58	**
Rent/Price [a]				
Var(Rent)/Price	0.0520	4.00 **	0.0513	4.12 **
Tenure	0.0186	1.21	0.0234	1.64
Farm Size	1.16e-5	1.94 *	7.94e-6	1.43
Economic Productivity Index	4.53e-5	0.50	0.0002	2.49 **
Population Density	-0.0001	-4.75 **	4.86e-5	-4.83 **
Constant	0.0402	2.27 **	-0.0097	-1.11
Spatial Coefficient (λ or ρ)	0.9178	11.22 **	0.9218	12.03 **
Pseudo $R^{2,(c)}$	0.61		0.76	
Log-likelihood	273.73		276.77	
LaGrange Test [d]	22.21	**	39.16	**

Notes: [a] Number of observations: 92 counties in Illinois.
[b] ** Significant at the 5 percent level; * significant at the 10 percent level.
[c] Pseudo R^2 is defined as the correlation between the sample's actual and predicted endogenous variables.
[d] LaGrange multiplier test, distributed as chi-square with one degree of freedom, tests the hypothesis of spatial error or spatial lag structure.

Table 5. Elasticities

Variable	OLS Models	Spatial Error Models	Spatial Lag Models
Price			
Rent	0.406	0.514	0.098
Var(Rent)	-0.060	-0.046	-0.022
Tenure	-0.192	-0.107	-0.171
Farm Size	-0.186	-0.152	-0.093
Econ. Prod. Index	0.005	0.005	0.005
Population Density	0.150	0.129	0.122
Rent/Price			
Var(Rent)/Price	0.106	0.089	0.087
Tenure	0.158	0.092	0.116
Farm Size	0.131	0.172	0.117
Econ. Prod. Index	0.006	0.001	0.004
Population Density	-0.098	-0.086	-0.082

Note: Elasticities are evaluated at the mean values.